Ultrafast Pinhole Camera Plasma Imager

Project Number: 96-29

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Purpose

The objective of the project is to develop ultrafast spacecraft measurements of ion relative wind velocity, temperature, and density. These similar measurements also need to be developed for calibrating the laboratory ion source during the testing of flight instruments before their launch.

Background

Studies from recent rocket flights have led to an increasing emphasis on very small-scale structures that are not well-resolved by the current instrumentation used. To better diagnose the low-energy plasma, we are developing the camera and detector technology required for faster accumulations and a higher sensitivity for low-energy particle images. The new system must be fast enough to resolve narrow plasma spatial features, must be space flight worthy, and must contain an integral retarding potential analysis capability.

The plasma camera that has been developed will also provide a significant enhancement of our routine plasma diagnostic capability for the ES83 Low Energy Electron and Ion Facility (LEEIF).

Approach

A microchannel plate (MCP) detector with a two-dimensional (2D) imaging anode will view the plasma through a simple pinhole aperture. An electron suppressor/RPA stack is placed in front of the pinhole. This instrument mounts on the leading surface of a spacecraft, viewing the rammed plasma. Figure 58 shows the artist's concept of the present 2D detector called PIVI or plasma ion velocity imager that has been developed. The ion image on the MCP is in the form of a spot whose position gives the 2D cross wind, whose size gives a measure of the transverse temperature (with knowledge of the ram velocity), and whose intensity gives a measure of the density. The spot dependence on the retarding potential yields information about the line of sight velocity and temperature. A moment computer will make fast calculations from the image to obtain the densities, temperatures, and velocities. Figure 59 shows the full experimental concept illustrating the pinhole camera, the XY position computer, the moments processor, and the data acquisition system.

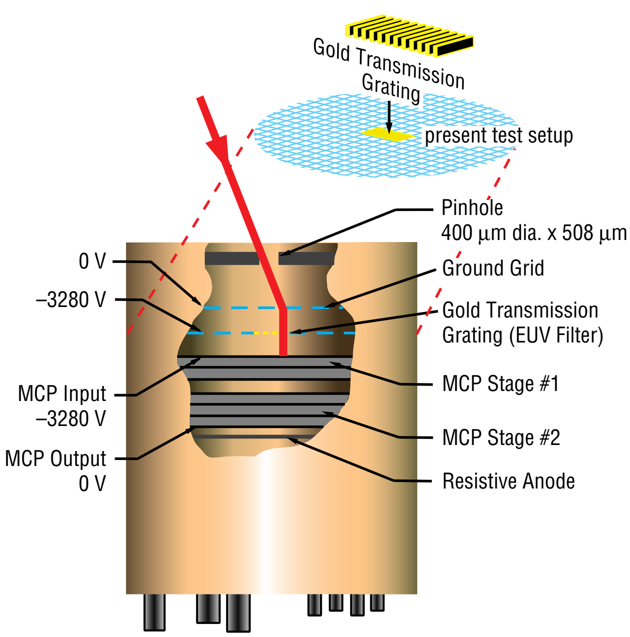

FIGURE 58.—Artist's concept of 2D detector plasma ion velocity imager (PIVI)

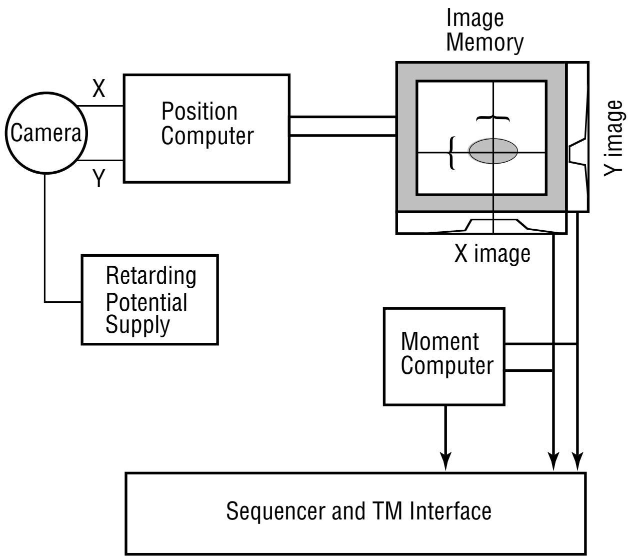

FIGURE 59.—Functional schematic of ultrafast pinhole camera.

Accomplishments

This past year, an extreme ultraviolet (EUV) filter approximately 1 by 2 cm in dimension was obtained from the Massachusetts Institute of Technology (MIT). This filter will be used to reject EUV from the detector and needs to be tested not only for this capability but for its charged particle transmission also. The grating was mounted on a front grid of the detector and tested with a charged particle source. Its transmission response was determined to be 11 percent, which is close to what was expected. Figure 60 shows the transmission of charged particles through the rectangular EUV filter which is mounted in the center of the microchannel plate.

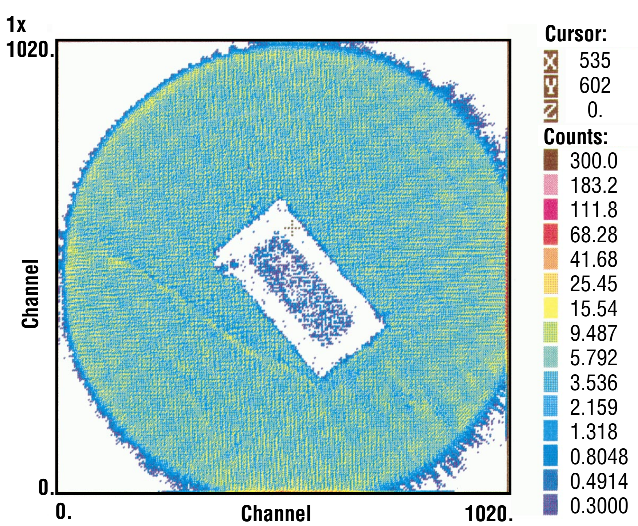

FIGURE 60.—Test with transmission grating.

During testing without the EUV filter, a spot image described as an annulus was continuously present. This annulus shows up as a large number of counts around a circle of small counts and was determined to be due to a local dead time phenomenon when the pores of the microchannel plates are receiving a very high count rate in a small localized area. A new set of plates was purchased that provides higher currents to the microchannels to reduce the dead time problem.

The instrument and its test results with the pinhole and the transmission grating were presented at a conference that focuses on new experimental concepts for relationships between space flight instruments and laboratory plasma instruments.

Planned Future Work

The planned work for FY98 includes testing the transmission grating with EUV particles to determine the magnitude of rejection. For space flight the order of rejection is required to be greater than 10^{-6}.

The high current microchannel plates are to be mounted and a test is to be conducted to find out if the local dead time phenomenon is reduced. It is hoped to see a factor of 10 increase in counts before the annulus appears.

The engineering group at EB23 will complete the electronic boards and the moments processor this year. Their unit is then to be tested with the remainder of the system.

Funding Summary ($k)

	FY96	FY97
Authorized:	46.7	40.3

The remaining funds, $3,872, have been carried into FY98.

Status of Investigation

Program funds of 46.7k were authorized for FY96 and 40.3k for FY97. The program has been carried into FY98 with the remaining funds so that EB23 can complete their engineering tasks. Successful results from the data acquisition tests using the moments processor and engineering boards provided by EB23 will mark the end of the proposed program. The project is to be completed at the end of FY98.